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The Currency Channel of the Global Bank Leverage Cycle*

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ABSTRACT

The amplitude of leverage procyclicality is heterogeneous across banks and across countries. This paper introduces international diversification of bank balance sheet as a factor of this observed heterogeneity, with a special emphasis on currency diversification. Based on a new theoretical framework, it shows that the impact of international diversification on leverage procyclicality depends on the relative performance of economies, the global business cycle and the exchange rate regime. By altering the distribution of global bank portfolio, international diversification adds a currency channel to the risk channel of the global leverage cycle. Using granular data on banks located in France, the paper shows that the pre-crisis international diversification of banks increased leverage procyclicality during the 2008-2009 crisis. Focusing on the currency channel, namely the valuation effect of currency diversification, results show that it had a negative effect on leverage procyclicality during this period, hence decreasing procyclicality. The currency channel contributed to offset part of the increased risk due to the crisis and the risk channel. These findings draw attention to the specific role of balance sheet currency diversification in financial stability risk.

Keywords: Bank, Financial Cycles, Leverage, Internationalization, International Portfolio, Currency

JEL classification: E32, F34, F36, F44, G15, G20

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NON-TECHNICAL SUMMARY

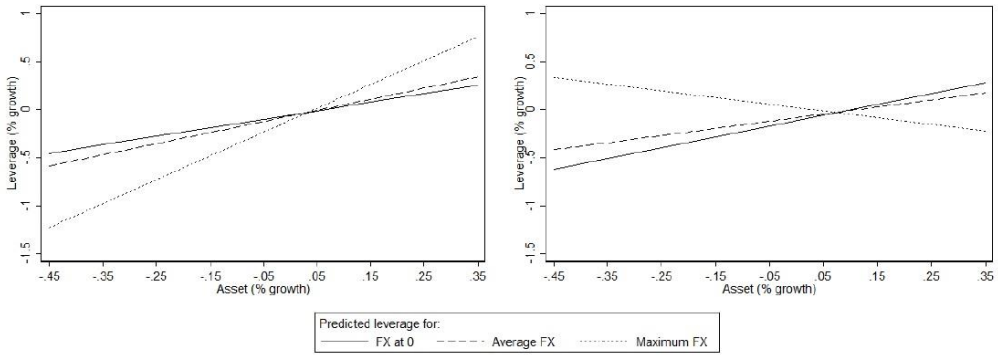
According to Adrian and Shin (2010, 2014), the amplitude of leverage procyclicality is heterogeneous across banks and across countries. This paper introduces international diversification of bank balance sheet as a factor of this observed heterogeneity, with a special emphasis on currency diversification. It first develops a contract model between the bank and its creditor with international assets and liabilities. It provides micro-foundations for a Value-at-Risk (VaR) rule where the probability of default of the bank – defined through the global portfolio return distribution – is constant over all states of the nature. To satisfy this rule, the bank and its creditor set the level of payoff and debt according to the state of nature. Assuming that the state of nature is reflected in the distribution of the portfolio return via a location parameter (i.e. the better the state of nature, the higher the location and the mean of the distribution), payoff, debt and leverage adjust to changes in this parameter and the associated risk environment. It provides a new theoretical framework to decompose the impact of diversification on bank leverage adjustments according to two channels, i.e. the risk channel and the currency channel.

In this paper, the distribution of the global portfolio return consists of a mixture of distributions between a domestic asset and a foreign asset in foreign currency. Because the location parameter of each distribution is a proxy of the state of nature of its related economy, changes in the states of nature affect the location of the global portfolio return distribution, as well as its tail risk. This direct effect is called the risk channel of diversification. The higher (*lower*) the risk introduced by diversification, the lower (*higher*) the leverage to satisfy the VaR rule. It follows that the risk channel accentuates leverage procyclicality when the foreign economic condition is more volatile than the domestic one, that is when it outperforms the domestic economic condition during booms but falls behind it during busts. The currency channel comes from the valuation effect on assets denominated in foreign currency. It affects the relative weight of each asset in the global portfolio. Foreign exchange rate is defined such that the currency with the higher interest rate (i.e. state of nature) typically appreciates. Therefore, the currency channel always promotes the asset that offers a better return in the portfolio. It directly changes the shape of the global portfolio return distribution by reducing its tail risk. It follows that leverage procyclicality – which refers to the cyclical variations of leverage according to the financial cycle – depends on the relative performance of economies, the global business cycle and the exchange rate regime.

The second part of the paper is devoted to an empirical event study to test theoretical predictions. Focusing on the Global Financial Crisis (GFC) that is associated to a negative foreign shock and a depreciation of the US dollar between end 2008 and end 2009, the model predicts that leverage procyclicality increases with diversification due to the risk channel but decreases with dollar depreciation due to the currency channel. Using granular French banking data on this period, results confirm theoretical predictions. Figure 1) depicts the predicted leverage procyclicality conditional on international diversification levels. Panel (a) shows procyclicality for different levels of diversification considering simultaneously the risk and the currency channel. Procyclicality increases significantly with international diversification, suggesting that the risk channel dominates the currency channel. Panel (b) focuses on the currency channel of diversification and shows that procyclicality decreases with diversification, possibly leading to a counter-cyclical leverage for the highest level of diversification.

Finally, the paper points out that international diversification is relevant to the procyclicality of leverage, even if banks use hedging strategies, such as financial instruments related to foreign currency exposure or a perfect match between foreign currency assets and liabilities. Considering home bias behaviour, the model is consistent with this hypothesis. However, currency diversification captures additional information. Assuming that bank behaviour is driven by the home bias hypothesis, all results would be driven by bank exposure to non-residents and currency diversification would have no explanatory power.

Figure 1: Predicted leverage procyclicality and international diversification:



(a) Risk and currency channel (b) Currency channel

The slope of each line measures the procyclicality of leverage. Each line expresses leverage procyclicality for different levels of international diversification. Three levels of diversification are considered: a minimum diversification equal to 0 (continuous line); an average diversification equal to the average level of diversification observed in the data (dashed line); a maximum diversification equal to the highest level of diversification observed in the data (dotted line). Panel (a) considers simultaneously the risk and the currency channel while panel (b) focuses on the currency channel. Procyclicality increases significantly with international diversification, suggesting that the risk channel dominates the currency channel. Considering the currency channel of diversification, procyclicality decreases with diversification possibly leading to a counter-cyclical leverage for the highest level of diversification

Le cycle du levier bancaire mondial : le canal de la devise

RÉSUMÉ

L'amplitude de la procyclicité de l'effet de levier est hétérogène entre les banques et entre les pays. Ce document de travail présente la diversification internationale du bilan des banques comme un facteur de cette hétérogénéité observée, avec un accent particulier sur la diversification des devises. D'un point de vue théorique, l'impact de la diversification internationale sur la procyclicité du levier dépend de la performance relative des économies, du cycle économique mondial et du régime de change. En modifiant la distribution du portefeuille bancaire, la diversification internationale ajoute un canal de la devise au canal du risque du cycle de levier mondial. En utilisant des données bancaires granulaires, l'analyse empirique confirme les hypothèses théoriques: la diversification internationale des banques a augmenté la procyclicité du levier pendant la crise de 2008-2009. En se concentrant sur le canal de la devise, à savoir l'effet de valorisation de la diversification monétaire, les résultats montrent qu'il a eu un effet négatif sur la procyclicité du levier durant cette période. Le canal de la devise a contribué à compenser une partie de l'augmentation du risque due à la crise. Ces résultats attirent l'attention sur le rôle spécifique de la diversification monétaire du bilan dans le risque de stabilité financière.

Mots-clés : banque, cycle financier, levier, globalisation, portefeuille international, devise

1 Introduction

The procyclicality of bank leverage has been a subject of keen interest, especially in the wake of the Global Financial Crisis (GFC). Following Geanakoplos [2009], Shin [2012] and Adrian and Shin [2014], leverage procyclicality refers to the cyclical variations of leverage according to the financial cycle. Extending their leverage during booms, banks strengthen the value of assets and create an endogenous mechanism similar to the financial accelerator ([Danielsson. et al., 2012]). Through the presence of global banks, it implies an amplification of global financial booms and busts associated with low and high level of risk, respectively (Adrian and Shin [2010, 2014]). All-in-all, this common and procyclical behavior of global bank leverage is a major source of economic instability (Geanakoplos [2009]).

The empirical literature on bank leverage procyclicality shows that procyclicality is not homogeneous across banks. For US, European and Canadian banks, it is subject to heterogeneity as banks located in different geographic areas show different levels of leverage procyclicality.[1] Especially when comparing US and European banks, Kalemli-Ozcan et al. [2012] show that European banks exhibit less procyclical leverage than their American counterpart, leaving the source of this heterogeneity unexplained.

At the macro level, international financial integration and banking involvement in international activities already explain the heterogeneous macroeconomic impact of the GFC across countries (Milesi-Ferretti et al. [2011]). Considering that European banks are particularly involved in international financial markets (Baba et al. [2009], Cerutti et al. [2017]), internationalization is expected to impact leverage procyclicality for these banks. Therefore, the purpose of this paper is to introduce bank internationalization as

[1] See Adrian and Shin [2010], Kalemli-Ozcan et al. [2012], Baglioni et al. [2013], Damar et al. [2013] for more details

a determinant of heterogeneous leverage procyclicality. I defined internationalization as the international diversification of bank's balance sheet in terms of assets and currencies of denomination. By altering the distribution of the global bank portfolio, international diversification adds a currency channel to the risk channel of the global financial cycle. The currency channel changes the sensitivity of banks to financial shocks and explains the observed heterogeneity in leverage procyclicality.

The ambiguity in the analysis of leverage procyclicality and internationalization is twofold. First, risk diversification is subject to several conditions, including conditions on the variance covariance matrix of asset returns. In fact, not all foreign exposures are alike. Second, the valuation effect associated to floating exchange rate and currency diversification depends on the characteristics of each currency. As for international exposures, not all foreign currencies are alike (Krogstrup and Tille [2016]).

To address this challenge and assess the impact of international diversification on leverage procyclicality, I develop a contract model a la Holmström and Tirole [1997] between the bank and its creditor where I introduce international assets and liabilities. This contract micro founds a Value-at-Risk (VaR) rule where the probability of failure of the bank is constant and the leverage adjusts to changes in the location parameters of the distribution of the bank portfolio. In this paper, the distribution of the portfolio consists of a mixture of distributions between a domestic asset and a foreign asset in foreign currency. It provides a new theoretical framework to decompose the impact of internationalization on bank leverage adjustments. Because the location parameter of each distribution is a proxy of the state of nature of its related economy, leverage - regardless of exchange rate regime - is a function of both the domestic and the foreign economic condition. The foreign exchange rate is endogenously defined as a function of the relative economic performance between the domestic and the foreign economy

and it captures the currency channel of the global financial cycle. As it changes bank sensitivity to financial shocks, the currency channel introduces heterogeneity in leverage procyclicality. This specification allows for a clear distinction between the risk channel linked to risk diversification and the currency channel due to the valuation effect of currency diversification. All in all, this paper offers a global and flexible theoretical framework to assess the impact of internationalization on leverage procyclicality, where both channels are detailed.

In the second part of the paper, I use granular and confidential data on banks located in France to test the theoretical predictions of the model. Focusing on the 2008-2009 crisis, I make use of the cross-section heterogeneity to see whether the pre-crisis international diversification conditions the adjustment of bank leverage during the GFC. It implies a one-time event analysis and eases the identification of the different channels through which international diversification impacts leverage procyclicality. Especially, specific measures of international diversification - including the currency diversification of bank balance sheet - allow to capture the currency channel of international diversification.

Valuation effect aside, the generalized conclusions of the model support the previous results of Kwok and Reeb [2000] on the upstream downstream hypothesis of internationalization. Leverage is then more procyclical with international diversification than without it when the foreign economy is more volatile than the domestic one, that is when the foreign economy outperforms the domestic economy during booms but falls behind it during busts. Especially during busts, international diversification shifts the portfolio distribution to the left and increases the tail risk of bank portfolio. Debt capacity is then reduced compared to the debt capacity based on a domestic portfolio: leverage procyclicality is increased by international diversification through the risk

channel. Assuming that the domestic currency appreciates when the domestic return rises with respect to the foreign one, the valuation effect shifts the portfolio distribution to the right and decreases the tail risk: the fund-raising capacity of the bank is increased by the currency channel. During busts, currency diversification then reduces leverage procyclicality. These theoretical predictions are confirmed empirically. International diversification - including both the diversification of risks and the valuation effect - increases leverage procyclicality during the GFC while the currency channel due to US dollar exposure decreases it.

This paper is related to several strands of the literature but with key differences. First, it is connected to the portfolio theory introduced by Markowitz [1952]. Especially, it considers the correlation of returns emphasized in Solnik [1974], the asymmetric impacts of internationalization on risk diversification depending on the financial cycle identified by Loging and Solnik [1995], and the relative volatility between the home and the target market stressed by Kwok and Reeb [2000] as a determinant of portfolio risk. By specifying conditions relative to the foreign exchange rate, this paper contributes to this literature where the foreign exchange rate risk is usually not specified. Second, this paper belongs to the literature which links leverage procyclicality to the VaR rule. Using a contract model between the bank and its creditor, Adrian and Shin [2014] micro-found the VaR rule and reproduce the procyclicality of leverage with a domestic portfolio. Acknowledging the global architecture of international banking, Bruno and Shin [2015] apply the VaR rule in a general framework with a global and a regional representative bank. While this framework provides a first insight on the role of international banking by capturing the aggregate leverage procyclicality as a function of a common risk factor, it does not explain the observed heterogeneity mentioned in Kalemli-Ozcan et al. [2012] either. Heterogeneity in leverage procyclicality is studied in Coimbra and Rey [2017] through the introduction of heterogeneous VaR thresholds to

explain heterogeneous banking participation in credit. However, they do not consider the international diversification of banks. Third, this paper is close to the recent empirical literature that introduces balance sheet heterogeneity as an additional variable to explain the adjustments of banking activity. Using aggregate data on European banks, Krogstrup and Tille [2018] use bank currency mismatch in net wholesale funding to explain the heterogeneous responses to global risk factor. With more granular data than Krogstrup and Tille [2018], Baskaya et al. [2017] focus on emerging markets and show that heterogeneity in the source of funding - domestic versus foreign - is the main driver of aggregate credit growth. By using granular data on the international diversification of bank balance sheet, my paper contributes to this recent literature by identifying the two channels of international diversification. Finally and considering that international diversification is one dimension of complexity, this paper is part of the growing literature on banking complexity and bank risk including Buch et al. [2013], Berger et al. [2017].

The rest of the paper is organized as follows. Section 2 introduces the theoretical model while section 3 develops the empirical analysis using innovative micro-data. Section 4 discusses liabilities and currency mismatch and section 5 concludes.

2 Model

2.1 Setting

The model is based on a representative bank balance sheet. The bank invests in assets and raises funds from its creditor. There are two currency denominations for assets and debts, corresponding to two different countries (domestic and foreign). The economic state of nature corresponding to each economy is known publicly.

The representative bank is domestic in the sense that its equity and its balance sheet

are in domestic currency. The bank is risk neutral and equity E is exogenous.[2] The second agent is the creditor of the bank, generally a Money Market Fund or another investment bank. The creditor lends money to the bank in both currencies (domestic and foreign). The creditor is also risk neutral. The exchange rate S is defined as the number of domestic units per unit of foreign currency.

There are two periods. At T=0, the bank raises funds backed by collateral in domestic and foreign currency (A and $A^\star$, respectively). Total assets expressed in domestic currency are equal to $A + SA^\star$. I denote by a the share of assets in domestic currency and $(1-a)$ the share of assets in foreign currency.[3] Funds are in domestic and in foreign currency (D and $D^\star$, respectively) and total funding expressed in domestic currency is equal to $D + SD^\star$. This debt is defaultable, implying that the creditor receives a defaultable debt claim at T=0.

At T=1, the bank receives a total expected return from its portfolio investment $a(1+\bar{r})+(1-a)(1+\bar{r}^\star)$, where $\bar{r}$ and $\bar{r}^\star$ are the expected returns from the domestic and the foreign asset, respectively. Stochastic returns depend on parameters that proxy the state of nature specific to each currency area, θ and $\theta^\star$, respectively. Specifically, θ and $\theta^\star$ are the location parameters of each return distribution that are used to define the portfolio distribution. The distribution of the portfolio returns consists of as a mixture of distributions weighted by the weight of each asset a and (1-a). They are known at the time of investment (T=0), meaning that both the bank and the creditor know the true distribution of returns. At T=1, the bank also reimburses its domestic and foreign debts,

[2] An exogenous equity is in line with the theory of procyclical leverage put forward by Shin. The hypothesis of a stable equity is supported by the pecking order theory (Jensen and Meckling [1976], Myers and Majluf [1984]). Issuing equity implies higher costs than debt and agency costs associated to inside versus outside equity holders. Therefore, banks issue equity in the last resort only, implying that equity is very sticky. The slow moving trend of capital is also observed in He and Krishnamurthy [2013], Acharya et al. [2013].

[3] Where a will vary depending on S. In this section, I consider S as fixed. Section 2.4 covers the case of a flexible exchange rate regime.

$\bar{D}$ and $S\bar{D}^{\star}$ respectively. It is assumed that $\bar{D} > D$ and $S\bar{D}^{\star} > SD^{\star}$ to remunerate the creditor for the default risk.

Hypothesis 1 *The location parameters of return distributions, θ and $\theta^{\star}$, are known and do not change for T=$\{0, 1\}$.*

Using General Extrem Value (GEV) distributions for each asset, the Cumulative Distribution Function (CDF) of the portfolio is defined such that:

$$\begin{aligned} F_{\theta,\theta^{\star}}(z) &= a\ F_{\theta}(z) + (1-a)\ F_{\theta^{\star}}(z) \\ &= a\ exp\left\{-\left(1+\xi\left(\frac{z-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} + (1-a)\ exp\left\{-\left(1+\xi\left(\frac{z-\theta^{\star}}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \end{aligned} \tag{1}$$

Where σ and ξ are respectively the scale parameter and the shape parameter.[4]Considering that the bank and the creditor of the bank are risk neutral, preference for the domestic asset and home bias are not considered in this model.[5] The definition of assets supports this hypothesis, i.e. the only difference between the domestic and the foreign asset is the location parameter.

The bank balance sheets at each period are given in table 1 where four debt ratios are defined relative to each funding currency and each period. The debt ratios at T=0 are:

$$d = \frac{D}{A + SA^{\star}} \quad \text{and} \quad d^{\star} = \frac{SD^{\star}}{A + SA^{\star}} \tag{2}$$

[4]See Reiss and Thomas [2007] for more details on GEV distributions.

[5]However, the model is flexible enough to introduce some frictions in the definition of a and $(1-a)$ to introduce an home bias.

T=0, at market value:

Assets	Liabilities
A	E
$SA^\star$	D
	$SD^\star$

T=1, at notional value:

Assets	Liabilities
$(1+\bar{r})A$	$\bar{E}$
$(1+\bar{r}^\star)SA^\star$	$\bar{D}$
	$S\bar{D}^\star$

Table 1: Bank balance sheet at T=0 and T=1

Alternatively, the corresponding ratios of notional values of debt at T=1 to total assets at the market value are:

$$\bar{d} = \frac{\bar{D}}{A + SA^\star} \quad \text{and} \quad \bar{d^\star} = \frac{S\bar{D}^\star}{A + SA^\star} \tag{3}$$

$\bar{E}$ is the equity at the notional value that sets the two sides of the balance sheet equal. The bank is expected to make profits such that $E < \bar{E}$ and $a(1+\bar{r}) + (1-a)(1+\bar{r}^\star) > (\bar{d} + \bar{d^\star})$.

The leverage λ is defined as the ratio of total assets to equity, at market value. It is a positive function of total debt ratios at the market value.

$$\lambda = \frac{A + SA^\star}{E} = \frac{A + SA^\star}{(A + SA^\star) - (D + SD^\star)} = \frac{1}{1 - (d + d^\star)} \tag{4}$$

2.2 Value at Risk rule

Using a contract model a la Holmström and Tirole [1997] between the bank and the bank's creditor, the bank and the creditor maximize their expected net payoff and set $(d + d^\star)$ and leverage as a function of θ and $\theta^\star$.[6] First, knowing the actual distribution of portfolio returns, the bank and the creditor identify at T=0 the potential payoff at T=1 that satisfies the Value at Risk (VaR) rule (i.e., the level of $(\bar{d} + \bar{d^\star})$ that holds the probability of default constant). Second, this potential repayment $(\bar{d} + \bar{d^\star})$ is part

[6]The appendix A.1 and A.2 provides full details on the contract model and the intermediate demonstration steps.

of the creditor's participation constraint: the higher the payoff $(\bar{d} + \bar{d^\star})$, the greater the creditor's participation. It defines the investment strategy, the total debt that the creditor is willing to lend to the bank at T=0 and the bank leverage.

The CDF defines the probability of default α where default appears if the realized total return falls below the total debt ratio at the notional value $((\bar{d} + \bar{d^\star}) \geq z)$. It implies that α increases with z but decreases with θ and $\theta^\star$:

$$\begin{aligned}\alpha(\bar{d} + \bar{d^\star}) &= F_{\theta,\theta^\star}(\bar{d} + \bar{d^\star}) \\ &= a\ exp\left\{-\left(1 + \xi\left(\frac{(\bar{d} + \bar{d^\star}) - \theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \\ &\quad + (1-a)\ exp\left\{-\left(1 + \xi\left(\frac{(\bar{d} + \bar{d^\star}) - \theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \qquad (5)\end{aligned}$$

The VaR rule derived from the contract model states that the probability of default is constant and equal to $\bar{\bar{\alpha}}$. Assuming that $\xi = -1$, the closed form solution of the VaR rule is such that:[7]

$$VaR = F_{\theta,\theta^\star}(\bar{d} + \bar{d^\star}) = \bar{\bar{\alpha}} \qquad (6)$$

The probability of default α is constant for any state of nature θ and $\theta^\star$ and any level of diversification. To satisfy equation (6), the bank adjusts the notional value of its debt ratio $(\bar{d} + \bar{d^\star})$. Note that the VaR rule focuses on the tail of the distribution. If the tail is thickened by a change in the states of nature, the bank has to decrease its total debt ratio in order to keep a constant $\alpha = \bar{\bar{\alpha}}$.

[7] $\xi = -1$ implies that the $F_{\theta,\theta^\star}(z)$ distribution has an upper bound: the support of the distribution is $\left(-\infty\ ,\ -\sigma ln\left(a.exp\left\{-\left(\frac{\sigma+\theta}{\sigma}\right)\right\} + (1-a)exp\left\{-\left(\frac{\sigma+\theta^\star}{\sigma}\right)\right\}\right)\right)$. As the VaR rule focuses on the left side of the distribution, this assumption is not a problem. It allows an approximation of a closed form solution.

Proposition 1 *Currency diversification does not affect the VaR rule. The bank adjusts its balance sheet to the state of nature in both currency areas:* $(\bar{d} + \bar{d}^{\star})$ *adjusts to* θ *and* $\theta^{\star}$ *in order to satisfy a constant* $\bar{\bar{\alpha}}$*.*

Developing the VaR rule, I obtain:[8]

$$VaR = \underbrace{exp\left\{\frac{(\bar{d} + \bar{d}^{\star}) - \theta}{\sigma} - 1\right\}}_{Baseline} \underbrace{\left[a + (1-a)exp\left\{\frac{\theta - \theta^{\star}}{\sigma}\right\}\right]}_{\Omega} = \bar{\bar{\alpha}} \tag{7}$$

The VaR rule defines bank debt ratio $(\bar{d} + \bar{d}^{\star})$ and its adjustment to the states of nature. Without diversification $a = 1$ or with similar economies $\theta = \theta^{\star}$, the left hand side of the VaR is reduced to the *Baseline* component. The bank debt ratio $(\bar{d} + \bar{d}^{\star})$ follows the states of nature where $\theta = \theta^{\star}$. In that case, conclusions are similar to Adrian and Shin [2014]. As the probability of default is constant, an increase in θ or $\theta^{\star}$ leads to a similar increase in the national value of bank debt. When diversification is introduced and $\theta \neq \theta^{\star}$, the VaR rule includes a factor Ω to the *Baseline* component. Ω measures the impact of international diversification on the tail of the distribution, i.e. the risk channel. When $\theta > \theta^{\star}$, $\Omega > 1$ and diversification implies a thickening of the tail of the distribution: the diversified portfolio becomes riskier than the baseline portfolio. In return, when $\theta < \theta^{\star}$, $\Omega < 1$ and the tail of the distribution becomes thinner than the tail of the baseline distribution. An international portfolio is safer than the baseline portfolio.

Proposition 2 *Under a fixed exchange rate, international diversification introduces a risk channel that increases the tail risk of banks* $(\Omega > 1)$ *when the domestic economic condition outperforms the foreign one* $(\theta > \theta^{\star})$*, while it decreases it* $(\Omega < 1)$ *when the foreign economic condition becomes better than the domestic one* $(\theta < \theta^{\star})$*.*

The adjustment of the bank debt ratio $(\bar{d} + \bar{d}^{\star})$ to the states of nature $\{\theta, \theta^{\star}\}$ is such

[8] Where $F_{\theta^{\star}} = F_{\theta} \,.\, exp\left\{\frac{\theta - \theta^{\star}}{\sigma}\right\}$

that:

$$(\bar{d}+\bar{d}^{\star}) = \underbrace{\theta+\sigma+\sigma ln\left(\bar{\bar{\alpha}}\right)}_{Baseline} - \sigma ln\left(\underbrace{a+(1-a)exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}}_{\Omega}\right) \tag{8}$$

When $\theta = \theta^{\star}$, $\Omega = 1$. It implies an unchanged tail risk: during booms the baseline $(\bar{d}+\bar{d}^{\star})$ increases while it decreases during bust. It defines the baseline leverage procyclicality. When $\theta > \theta^{\star}$, $\Omega > 1$ and the tail risk increases: the increase in bank debt ratio is then less pronounced during booms than the baseline framework would predict. $(\bar{d}+\bar{d}^{\star})$ is less procyclical than in the baseline. On the contrary during bust, the decrease in $(\bar{d}+\bar{d}^{\star})$ is more pronounced than the baseline framework would predict: procyclicality increases. When $\theta^{\star} > \theta$, $\Omega < 1$ and the tail risk decreases: during booms, international diversification increases the procyclicality of $(\bar{d}+\bar{d}^{\star})$, but it decreases it during bust.

Proposition 3 *Currency channel aside, leverage procyclicality increases with international diversification because of the risk channel when the foreign economic condition is more volatile than the domestic one. When the foreign state of nature becomes less volatile than the domestic one, leverage procyclicality then decreases.*

The participation compatibility constraint derived form the maximization of utilities implies that $(d+d^{\star})$ is a positive function of $(\bar{d}+\bar{d}^{\star})$. Therefore, previous conclusions on $(\bar{d}+\bar{d}^{\star})$ are applied to leverage procyclicality given that:

$$\lambda = \frac{1}{1-(d+d^{\star})} \tag{9}$$

Figure 1 depicts the procyclicality of banking activities conditional to different states of nature. Because equity is sticky, total banking activities are determined by leverage, implying procyclical fluctuations of total credits.[9] The baseline scenario corresponds to

[9]Total assets are defined such that: $(A+SA^{\star}) = \lambda E$. It is the maximum total assets allowed by the

the case where the two economies are similar, implying that $\theta = \theta^{\star}$. As pictured in the figure, leverage procyclicality is increased by international diversification during booms but decreased by it during busts when the foreign economy outperforms the domestic economy (green line). When the domestic economy outperforms the foreign economy, leverage procyclicality is then decreased by international diversification during booms but increased by international diversification during busts (green line).

{ *Insert Figure 1 here* }

It follows that, valuation effect aside, international diversification introduces a risk channel that accentuates leverage procyclicality when the foreign economic condition is more volatile than the domestic one, that is when it outperforms the domestic economic condition during booms but falls behind it during busts (red line in figure 1).[10] Conversely, leverage procyclicality weakens with the risk channel of international diversification when the foreign state of nature is less volatile than the domestic one. Those generalized conclusions support previous results from Kwok and Reeb [2000] which visit the upstream downstream hypothesis of internationalization.

It is important to note that the model does not consider home bias in lending. Banks and creditors are risk neutral agents that adjust their activities relative to portfolio characteristics and expected value of return and reimbursement. Banks adjust leverage to increased risk in equal manner whether risk comes from home or from the foreign

contract model with sticky equity. Introducing regulatory instruments such as Countercyclical capital buffer (CCyB) would reduce this pass-through.

[10] It is important to note that the model does not consider home bias in lending. Banks and creditors are risk neutral agents that adjust their activities relative to portfolio characteristics and expected value of return and reimbursement. Banks adjust leverage to increased risk in equal manner whether risk comes from home or from the foreign economy. The home bias theory suggests a flight home effect where banks are more sensitive to shocks abroad (Cetorelli and Goldberg [2011], Giannetti and Laeven [2012], De Haas and Van Horen [2013]). Considering home bias behavior, the adjustment of banking activities linked to the risk channel of diversification - as defined in the model - would be exacerbated by a general retrenchment of foreign exposures because of risk aversion of domestic banks. Although home bias is not presented in the model, it is consistent with the risk channel of diversification. In both mechanisms, an increase in foreign risk leads to a decrease in banking activity. This reaction could be stronger considering home bias. Appendix C discusses the home bias hypothesis in more details.

economy. The home bias theory suggests a flight home effect where banks are more sensitive to shocks abroad (Cetorelli and Goldberg [2011], Giannetti and Laeven [2012], De Haas and Van Horen [2013]). Considering home bias behavior, the adjustment of banking activities linked to the risk channel of diversification - as defined in the model - would be exacerbated by a general retrenchment of foreign exposures because of risk aversion of domestic banks. Although home bias is not presented in the model, it is consistent with the risk channel of diversification. In both mechanisms, an increase in foreign risk leads to a decrease in banking activity. This reaction could be stronger considering home bias.[11]

2.3 The currency channel

In previous sections, the foreign exchange rate is assumed to be fixed. Floating exchange rate regime affects the weight of assets in the bank portfolio since $a = \frac{A}{A+SA^\star}$. Depending on the correlation between the exchange rate and asset returns, a floating exchange rate will impact the portfolio distribution and leverage adjustments.

The extensive empirical literature on the relationship between foreign exchange rates and the state of nature of the economy or between foreign exchange rates and interest rates suggests that domestic macroeconomic performances or relative domestic return performances are associated with domestic currency appreciation. [12]

Hypothesis 2 *The domestic currency appreciates when the domestic return rises with respect to the foreign one.*

[11] Appendix C discusses the home bias hypothesis in more details.

[12] Using high frequency data and macroeconomic announcements in the U.S or in Germany in the 1990s, Andersen et al. [2003, 2007], Faust et al. [2007] show that the foreign exchange rate is linked to macroeconomic fundamentals: a stronger than expected release appreciates the domestic currency. Regarding interest rates, Engel [1996] shows that the currency with the higher interest rate typically appreciates. Using structural VAR with daily data from 1988 to 2004, Ehrmann et al. [2011] show that the euro is also positively affected by shocks on short rates where a rise in euro area short rates leads to a euro appreciation. Finally, Itskhoki and Mukhin [2017] define a theoretical model reproducing the different foreign exchange rate puzzles identified in the literature, including the Engel [1996] result.

The exchange rate S is defined as a function of location parameters θ and $\theta^\star$ which are known by the bank and the creditor at T=0. Based on the value of θ and $\theta^\star$, S is given for the two periods included in the contract, T=$\{0,1\}$. The process of S relative to portfolio returns is given by equation (10) where returns depend on the state of nature of both economies and on a function of the shape parameter $H(\xi)$:

$$S = 1 + \frac{r_{\theta^\star} - r_\theta}{1 + r_\theta} \tag{10}$$

Where :

$$r_{\theta^\star} = \theta^\star + \sigma H(\xi)$$

$$r_\theta = \theta + \sigma H(\xi)$$

$$\lim_{r_\theta \to \infty} S(r_\theta) = 0 \ , \ \text{and} \ \ S = 1 \ \leftrightarrow \ r_\theta = r_{\theta^\star}$$

Because I want to extract the currency channel of international diversification, I assume that the bank does not change the composition of its portfolio, notwithstanding small changes in states of nature.[13] When the domestic currency appreciates, the converted value of the foreign asset declines, which leads to a larger share of domestic assets relative to total assets: a goes up at T=$\{0,1\}$. Consequently, changes in a and $(1-a)$ only reflect the exchange rate effect on converted value, so called the valuation effect of international diversification. This makes it possible to identify the currency channel of diversification on leverage.

Hypothesis 3 *Changes in a only reflect valuation effects due to variations in the ex-*

[13]This implicit assumption seems to be reasonable regardless of the time horizon because of both the transaction costs and the international dimension of the foreign currency. Odean [1998], Liu and Strong [2008] justify the "buy and hold" strategy for short term horizon because of the transaction costs implied in rebalancing strategies. Following Liu and Strong [2008], a monthly rebalancing strategy is then unrealistic. In addition, the foreign currency included in the model is considered as an international currency. Because of the international involvement of global banks, there is an incompressible share of assets and liabilities denominated in foreign currency. A complete re-allocation from one currency to another would then imply a complete change in the bank business model, going from global to national and vice-versa, or a complete change in the definition of the international monetary system. It seems reasonable to think that such adjustments are rare and sluggish.

change rate, that is $\frac{da(S)}{dS} < 0$.

One can rewrite equation (8) where a is a function of S such that:

$$(\bar{d} + \bar{d^\star}) = \theta + \sigma + \sigma ln\left(\bar{\bar{\alpha}}\right) - \sigma ln\left(\underbrace{a(S) + (1 - a(S))\ exp\left\{\frac{\theta - \theta^\star}{\sigma}\right\}}_{\Omega_S}\right) \tag{11}$$

$$\text{With } \frac{da(S)}{dS} < 0$$

Because a floating exchange rate always promotes the asset which offers a better return in the portfolio, S directly affects the tail of the portfolio distribution through Ω_S. Compared to a fixed exchange rate regime, the introduction of S always decreases the thickness of the distribution tail. As the bank still follows the VaR rule, the floating exchange rate regime increases its capacity to raise funds compared to its debt capacity in a fixed exchange rate regime.

Proposition 4 *Introducing a floating exchange rate, the currency channel decreases the tail risk of banks and increases their fund-raising capacity as long as the two economies are different, that is* $\frac{d(\bar{d}+\bar{d^\star})}{dS} > 0$ *when* $\theta^\star > \theta$ *or* $\frac{d(\bar{d}+\bar{d^\star})}{dS} < 0$ *when* $\theta^\star < \theta$.

The currency channel is observed through the derivative of $(\bar{d} + \bar{d^\star})$ relative to S when θ and $\theta^\star$ are constant:

$$\frac{d(\bar{d} + \bar{d^\star})}{dS} \mid \theta, \theta^\star = -\sigma \frac{\left(\frac{da_{(S,\theta,\theta^\star)}}{dS} \mid \theta, \theta^\star\right)\left(1 - exp\left\{\frac{\theta-\theta^\star}{\sigma}\right\}\right)}{a + (1-a)exp\left\{\frac{\theta-\theta^\star}{\sigma}\right\}} \tag{12}$$

S does not affect $(\bar{d} + \bar{d^\star})$ when $\theta = \theta^\star$. However, an appreciation of the foreign currency (i.e S increases) leads to an increase in $(\bar{d} + \bar{d^\star})$ when:

$$\left(\frac{da_{(S,\theta,\theta^\star)}}{dS} \mid \theta, \theta^\star\right)\left(1 - exp\left\{\frac{\theta - \theta^\star}{\sigma}\right\}\right) < 0 \tag{13}$$

Because $\left(\frac{da_{(S,\theta,\theta^\star)}}{dS} \mid \theta, \theta^\star\right) < 0$, then the condition becomes $\theta^\star > \theta$. Foreign currency

appreciates when the the foreign economy outperforms the domestic one, leading to an increase in the fund raising capacity. Alternatively, an appreciation of the domestic currency leads to an increase in $(\bar{d} + \bar{d}^{\star})$ when $\theta > \theta^{\star}$. The conditions allowing an increase in fund raising capacities depend on the definitions of the model. The difference in the states of nature defines the exchange rate adjustment while $\left(\frac{da_{(S,\theta,\theta^{\star})}}{dS} \mid \theta, \theta^{\star}\right) < 0$ defines the portfolio adjustment relative to the exchange rate. In this framework, the currency channel always increases the bank fund raising capacity compared to a fixed exchange rate regime as long as $\theta \neq \theta^{\star}$.[14]

Combining both the risk channel and the currency channel introduces conditions for leverage counter-cyclicality. When the domestic economy outperforms the foreign one during a bust, $\theta > \theta^{\star}$, leverage procyclicality is increased by the risk channel but decreased by the currency channel. Similarly, when the foreign economy outperforms the domestic one during a bust, $\theta^{\star} > \theta$, leverage procyclicality is decreased by both the risk and the currency channel. If the valuation effect is strong enough during economic busts, leverage may then become counter-cyclical under specific conditions.[15] When $\theta > \theta^{\star}$, the condition for a counter-cyclical leverage relative to the foreign economic condition is such that:

$$\underbrace{(1-a)\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}} \mid \theta\right)^{-1}}_{Portfolio\ adjustment} < \sigma \underbrace{\left(\frac{1}{exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}} - 1\right)}_{\Delta Economic\ condition} \tag{14}$$

The counter-cyclical condition in equation (14) compares the portfolio adjustment due to the valuation effect to the relative economic performance going from $\theta = \theta^{\star}$ to $\theta > \theta^{\star}$. As $\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}} \mid \theta\right) < 0$, the higher the initial share of foreign asset, the more the bank ben-

[14] The increase in the fund raising capacity comes from the portfolio adjustment due to floating exchange rate. Under a stable portfolio composition, leverage adjustment follows previous conclusions under fixed exchange rate.

[15] See the appendix A.2 for more details.

efits from the currency channel and the more validated the condition would be. Because the foreign economy is busting, the domestic currency appreciates and the valuation effect promotes the domestic asset in bank portfolio: the valuation effect decreases the tail risk and offsets the economic bust.

When the domestic economy contracts ($\theta < \theta^{\star}$), a counter-cyclical leverage relative to the domestic economic condition is observed when the valuation effect is larger than the decline in economic condition. With $\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta} \mid \theta^{\star}\right) > 0$, the condition becomes:

$$\underbrace{a\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta} \mid \theta^{\star}\right)^{-1}}_{Portfolio\ adjustment} < \underbrace{\sigma\left(1 - exp\left\{\frac{\theta - \theta^{\star}}{\sigma}\right\}\right)}_{\Delta Economic\ condition} \tag{15}$$

The lower the initial share of domestic asset in the bank portfolio, the more beneficial the valuation effect is and the more validated the condition would be.

The net impact of international diversification on leverage procyclicality then depends on two channels (i.e. the risk and the currency channel) that consider the relative performance of the two economies, the business cycle, and the exchange rate regime.[16]

3 The currency channel during the Global Financial Crisis

Focusing on the 2008-2009 crisis, the theoretical model predicts that banks with exposures to the US and the US dollar are supposed to show different leverage procyclicality. Considering banks in France and the major economic and financial negative shock coming from the US during the 2008-2009 crisis, the risk channel of international diversification is expected to increase leverage procyclicality during this period. Focusing on the currency channel of international diversification, however; it would have a negative

[16]See table A.1 in the appendix A.3 for a complete summary of the theoretical predictions.

impact on leverage procyclicality. This section tests the theoretical predictions using micro-data on banks located in France during the 2008-2009 crisis.

3.1 Data

I use a unique micro-data from the French banking supervision authority ACPR. It consists of foreign and French banks located in France and it provides yearly information on consolidated bank balance sheet and derivatives relative to foreign exchange rate operations, and on a proxy of the currency diversification of assets. All data are collecting at the book value.[17] Additionally, it provides information on bank characteristics such as the nationality of banks and the sub-category the banks are attached to (banks, cooperative banks, financial and investment firms).

Focusing on the 2008-2009 crisis, the sample consists of 26 banks composed of 18 and 8 French and foreign banks, respectively. Table 2 provides descriptive statistics on all banks focusing on bank size defined as the logarithm of total assets, leverage defined as the ratio of total assets to equity, US dollar diversification FX_{2007} defined as the share of assets denominated in US dollar, currency mismatch CM defined as the ratio of net US dollar exposure to total assets and, derivatives relative to foreign exchange operations defined as the ratio of those derivatives to total assets. Detailed information on international diversification and currency mismatch is provided based on euro area counterparty. US dollar diversification with euro area counterparties $FX(EA)$ is defined as the share of total assets denominated in US dollar and including a euro area counterparty while $FX(n\text{-}EA)$ is the share of total assets denominated in US dollar with counterparties outside the euro area. Similarly, $CM(EA)$ is the currency mismatch ratio limited to euro area counterparties, while $CM(n\text{-}EA)$ focuses on the rest of the world. All variables come from accounting collections measured at the end of each period.

[17] See the appendix B for more details on the dataset

{ *Insert Table 2 here* }

Following table 2, banks had an average US dollar diversification of 12% of total assets in 2007, while the FX derivative ratio reached 0.54 on average for the same year. Currency mismatch is limited on average except for exposures with counterparties located outside the euro area. Focusing on standard deviations, minimum and maximums, heterogeneity is observed in all variables reported in table 2. Tables 3 and 4 provide additional descriptive statistics focusing on French or foreign banks. Comparing the two tables, foreign banks are more diversified in 2007 than French banks. The main difference is explained by the geographic counterparty of assets. On average in 2007, 23% of foreign banks' assets are denominated in US dollar with a counterparty outside the euro area, while the French banks only declare 3% of their total assets. Foreign banks also manifest stronger decline in leverage and size during the financial crisis than their French counterparts.

{ *Insert Table 3 here* }

{ *Insert Table 4 here* }

3.2 An event study

I focus on the impact of international diversification on leverage procyclicality during the 2008-2009 crisis. Especially, I want to test whether the pre-crisis international diversification of assets, i.e in 2007, affects the large adjustment of bank balance sheet during the crisis, i.e between 2008 and 2009. My quantitative analysis is thus based on cross-section heterogeneity between banks.

I follow previous empirical strategies used in Adrian and Shin [2010], Kalemli-Ozcan et al. [2012], Baglioni et al. [2013], Damar et al. [2013] where the growth rate of leverage between 2008 and 2009 is the dependent variable and the value of leverage in 2008 and

the growth rate of assets between 2008 and 2009 are the main explanatory variables.[18] Leverage procyclicality is then measured with the coefficient β_2 in equation (16). I extend the specification by introducing an interaction term between the growth rate of assets between 2008 and 2009 and the level of international diversification in 2007 $FX_{i,2007}$. The coefficient β_3 then measures the net impact of international diversification on leverage procycliclality.[19] The level of international diversification, $FX_{i,2007}$, is introduced separately as a control variable. Since banks can hedge their foreign exchange exposure using financial instruments such as derivatives, the ratio of foreign exchange derivatives in 2007, $Deriv_{i,2007}$, is part of the specification as control variables. In doing so, I control for hedging strategies that could influence the currency channel of international diversification.[20] Finally, to control for unobserved heterogeneity between banks I introduce several dummy variables δ_i including a French nationality dummy variable and dummy variables capturing the category of banks. The dummy for French nationality controls for the fact that leverage may adjust differently during the crisis whether banks are French banks located in France or French affiliates of foreign banks.[21] Banking categories cover general banks, cooperative banks, specialized banks (i.e ECS) and specialized financial institutions (i.e IFS). ECS are specialized in specific financial activities including consumer loans and mortgage financial leases, while IFS are credit institutions with a specific mandate defined by public authorities. These dummy variables for bank category and nationality remove issues related to omitted factors that potentially co-determine both the choice of international diversification prior the financial crisis as

[18] Δ stands for the first-difference of the logarithm.

[19] The risk of reverse causality between the crisis leverage adjustment and the pre-crisis international diversification is limited because of the unexpected nature of the financial crisis. The idea of reverse causality implies that the choice of international diversification is determined by future leverage adjustment (or targeted leverage adjustment). Applying this hypothesis to the financial crisis, it would mean that banks have chosen their pre-crisis international diversification in order to achieve their crisis leverage adjustment. As financial crisis are by definition unexpected, then the risk of reverse causality seems to be reduced.

[20] Hedges on currency exposures could also be specific to the bank's borrowers if they themselves are hedged against currency exposures (i.e., exporters), however, this degree of information is not detailed in the data set.

[21] Appendix C provides additional results to discuss heterogeneity between domestic and foreign banks

well as the movement of leverage afterward.[22]

$$\begin{aligned}\Delta Leverage_{i,2008-09} = \alpha + \beta_1\ ln(Leverage_{i,2008}) + \beta_2\ \Delta Asset_{i,2008-09} \\ + \beta_3\ (\Delta Asset_{i,2008-09}\ \text{x}\ FX_{i,2007}) + \beta_4\ FX_{i,2007} \\ + \beta_5\ Deriv_{i,2007} + \sum_{j=6}^{10} \beta_j \delta_{j,i} + u_i \end{aligned} \tag{16}$$

The variable FX_{2007} captures both the risk and the currency channels. In order to capture the valuation effect of international diversification I extend the analysis by replacing the share of assets denominated in US dollar by the share of assets denominated in US dollar with euro area counterparties $FX(EA)$.[23] Considering the euro area counterparty as a resident counterparty, this new measure focuses on the currency channel of international diversification. Alternatively, I introduce the share of assets denominated in US dollar with non-euro area counterparties $FX(n\text{-}EA)$ in order to have a complete decomposition of FX. An alternative to test the robustness of my results might be to replace the international diversification measure by the FX derivative measure as it focuses on derivatives relative to foreign exchange operations only. This last specification implies to introduce the international diversification measure as a control variable.

3.3 Results

Table 5 reports results from the different specifications of (16). For all specifications, results confirm previous conclusions from the literature: leverage is a mean reverting process and it is procyclical. However, my results also show that leverage procyclicality depends on international diversification.

[22]Because of their specific activities, then ECS and IFS are not expected to show either large international diversification or large leverage procyclicality compared to general banks. Similarly, foreign banks located in France are expected to have more international diversification than French banks; but they are also expected to be more procyclical than French banks as they are the first adjustment variable for foreign global banks during financial crisis.

[23]The share of assets denominated in euro with US counterparties or with non-euro area counterparties captures the risk channel. However, that information is not available in the current database.

{ *Insert Table 5 here* }

Focusing on international diversification with all conterparties FX_{2007}, the results show that international diversification had increased leverage procyclicality during the crisis. This first conclusion is robust even when the pre-crisis international diversification is defined in 2006 instead of 2007. However, the measure of international diversification FX captures the two channels of international diversification. Due to the floating exchange rate regime and the depreciation of the US dollar between the end of 2008 and the end of 2009, the theoretical model predicts a decrease in leverage procyclicality due to the currency channel.[24] Therefore, results reported in column (1) and (5) suggest that the net impact of international diversification is dominated by the risk channel (i.e the risk channel dominates the currency channel). To capture the currency channel, I introduce the variable $FX(EA)$ in column (2) and (6). The results confirm the theoretical prediction where the currency channel captured by $FX(EA)$ reduces leverage pro-cyclicality. Comparing the different results between column (1) and (2) and between column (5) and column (6), my results suggest that the risk channel, apart from the currency channel, increases leverage procyclicality. Column (3) and (7) introduce $FX(n\text{-}EA)$ and confirm the increase in leverage procyclicality due to non-resident counterparties. My results also support the implicit assumption that banks do not change their portfolio allocation at each period.[25] Finally, the ratio of the FX derivative $Deriv$ as an alternative measure of the valuation effect supports my conclusions at least when the measure is taken in 2007.

More broadly, the results indicate that currency diversification captures additional information that gives another dimension to the analysis compared to the home bias

[24]Between December 2008 and December 2009, the US dollar depreciated by 8.66% against the euro (ECB data).

[25]If banks re-allocate their portfolio at each period, then the number of lags used for currency diversification would be decisive to capture the effect of pre-crisis international diversification on leverage procyclicality during the crisis.

behavior. Assuming that bank behavior is driven by the home bias hypothesis, all results would be driven by bank exposure to non-residents and currency diversification would have no explanatory power. The home bias is consistent with the international diversification risk channel, however, the currency channel that focuses on the foreign currency of denomination (i.e. with resident exposure) differs from it.[26]

Figure 2 illustrates the previous results and reports the predicted leverage procyclicality for different levels of 2007 pre-crisis international diversification. The net impact of international diversification increases leverage procyclicality when currency diversification goes from 0 to the average value (i.e 0.12). When the maximum pre-crisis international diversification is assumed (i.e 0.71), the slope of the line is even more stronger than previously, translating the large sensitivity to foreign economic choc.

{ *Insert Figure 2 here* }

Focusing on the currency channel, the predicted leverage pro-cyclicality is lower for average value of pre-crisis international diversification (i.e. 0.03) than for 0 international diversification, even if this average pre-crisis international diversification is quite low. Interestingly, my results also supports the theoretical prediction of a counter-cyclical leverage associated with the currency channel and significant pre-crisis international diversification.

4 Discussion on liabilities and currency mismatch

The previous theoretical conclusions identify the states of nature and the foreign exchange rate regime as the two driving forces of leverage fluctuation: total converted debt adjusts to changes in total converted asset. The model - as defined in this paper - excludes a risk-free interest rate and a monetary policy interest rate, implying a limited

[26] Appendix C provides additional results to discuss the home bias hypothesis.

role in leverage procyclicality of liabilities. The participation constraint and an incentive constraint introduced by the contract model micro-found the VaR rule. Introducing a risk-free interest rate removes the contracting model and fails to micro-found the VaR rule. The framework defined in this paper is still compatible with a potential monetary policy interest rate as long as the interest rate defined by the contracting model stays above the monetary policy interest rate.[27]

Because total converted debt adjusts to changes in total converted asset, currency mismatch does not affect leverage procyclicality either. The bank supports foreign exchange rate fluctuations only through its total portfolio returns. The impact of foreign exchange rate fluctuations on bank debt is supported by the creditor of the bank. Assuming that the bank only invests in domestic asset while it raises debt in foreign currency, leverage is not going to be sensitive to fluctuations of exchange rate. An improvement of the foreign economic condition and the associated appreciation of the foreign currency do not change the portfolio distribution: leverage, total converted debt and reimbursement are unchanged. Implicitly, it means that the appreciation of the foreign currency is internalized by the bank creditor. Total converted debt and reimbursement stay unchanged, but total debt and reimbursement in foreign currency decrease.

Table 6 reports results from the different specifications of (16) using different measures of currency mismatch CM, $CM(EA)$, $CM(n\text{-}EA)$ and $CM(dummy)$. CM is defined as the ratio of net US dollar exposures to total assets. It captures the currency diversification of assets controlling for currency diversification of debts. The coefficient of the interaction variable is positive and significant, suggesting that asset currency diversification still increases leverage procyclicality when debt currency diversification is

[27] In Bruno and Shin [2015], Coimbra and Rey [2017], the VaR rule is directly implemented to constrain bank leverage. The interest rate on deposits is then risk-free or exogenous, introducing a second source of adjustment for banking leverage on the liability side: the monetary policy. However, this framework does not enable the microfoundations of the VaR rule as in Adrian and Shin [2014].

controlled for. Column (2) and (3) and column (6) and (7) use $CM(EA)$ and $CM(n\text{-}EA)$ to consider resident and non-resident counterparties of net US dollar exposures, respectively. Regarding euro-area counterparties $CM(EA)$, the coefficient of the interaction variable is negative and significant. It supports previous results where the valuation effect reduces leverage procyclicality. Similarly, the coefficient of the interaction variable related to $CM(n\text{-}EA)$ is positive and significant.

{ *Insert Table 6 here* }

CM, $CM(EA)$ and $CM(n\text{-}EA)$ capture the net US dollar exposures of banks. It controls for the currency diversification of liabilities; however, it does not test the potential effect of currency mismatch. To test this hypothesis, I use a dummy variable $CM(dummy)$ to identify significant currency mismatch (i.e currency mismatch larger than 1% of total assets). It concerns 50% of banks included in the sample. Results are detailed in column (4) and (8) and confirm the neutrality of currency mismatch. The coefficient of the interaction variable is insignificant.[28]

5 Conclusion

This paper provides a new adjusted framework to global banks with two currency denominations for assets and debts, corresponding to two different countries. It implies a diversification of risks between the two countries and a currency channel from floating exchange rate.

The international dimension of banking activities associated to the Value-at-Risk rule offers a new framework to explain the heterogeneous procyclicality of leverage. The international diversification of balance sheet plays a key role, especially if currency diversification is considered. When the foreign economy outperforms the domestic economy,

[28] Conclusions are robust to additional definitions of $CM(dummy)$, including larger thresholds than 1%.

a international diversification reduces risk in bank portfolio. International diversification then increases leverage procyclicality during booms but decreases it during busts as it expands the bank capacity to raise funds. Inversely, risk in bank portfolio gets larger with international diversification when the domestic economy outperforms the foreign one: international diversification decreases leverage procyclicality during booms but increases it during busts. More broadly, international diversification increases leverage procyclicality when it implies a foreign economic condition that is more volatile than the domestic economic condition. Introducing a floating exchange rate then expands the bank capacity to raise funds, since currency appreciates when its associated economy outperforms others. Bank leverage procyclicality then depends on the relative performance of countries, the business cycle, the level of currency diversification and the exchange rate regime.

This new international framework allows to make use of cross-sectional data on bank balance sheet. Focusing on banks located in France during the 2008-2009 crisis, my results show that leverage procyclicality positively depends on pre-crisis international diversification. The higher the international diversification before the crisis, the stronger the leverage response to assets variations during the 2008-2009 crisis. This net impact of international diversification suggests that the risk channel dominates the currency channel. Focusing on the currency channel of international diversification, my results show that it reduces leverage procyclicality during the crisis. Therefore, the empirical results yield supporting evidence to the theoretical predictions where the domestic economy outperforms the foreign economy during a bust.

This paper underlines the specific role of international diversification in financial stability risk and economic stability. As not all foreign currencies and foreign economies are alike, this paper shows that the impact of international diversification would differ ac-

cording to which currency denomination is included. Therefore, policy recommendations on international banking activities need to be identified in respect to the characteristics of foreign exchange rates and the relative economic and financial performances.

This paper offers a large range of potential extensions. First, a major advantage of this model is its flexibility, especially regarding the definition of exchange rate and the portfolio rebalancing behavior. Changing the bank strategy from a "buy and hold" strategy to an active rebalancing strategy can be described simply by changing the assumption on the portfolio adjustments to economic conditions. Then, this paper suggests that the amplification of economic booms and busts due to leverage cyclical variations depends to the extent of international banking activities. Applying this model to a general equilibrium model may then provide an interesting framework for future research. Finally, this paper raises the question of asymmetries between booms and bust, especially if the volatility of the economic conditions is time varying. Extending the quantitative analysis to both a panel data analysis and a broader currency portfolio is a subject of keen interest.

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Figure 1: **Leverage procyclicality.** The two graphs picture credit fluctuations conditional to different states of nature, θ and $\theta^{\star}$. The dashed line illustrates credit fluctuations due to changes in the positive Net Present Value (NPV) of total assets. The black line describes credit fluctuations due to leverage procyclicality when $\theta = \theta^{\star}$ (baseline scenario). The green line and the blue line show credit fluctuations when $\theta^{\star} > \theta$ and $\theta > \theta^{\star}$, respectivelly. The case where $\theta^{\star} > \theta$ during booms and $\theta > \theta^{\star}$ during burst is illustrated with the red line ($\theta^{\star}$ shows larger volatility than θ).

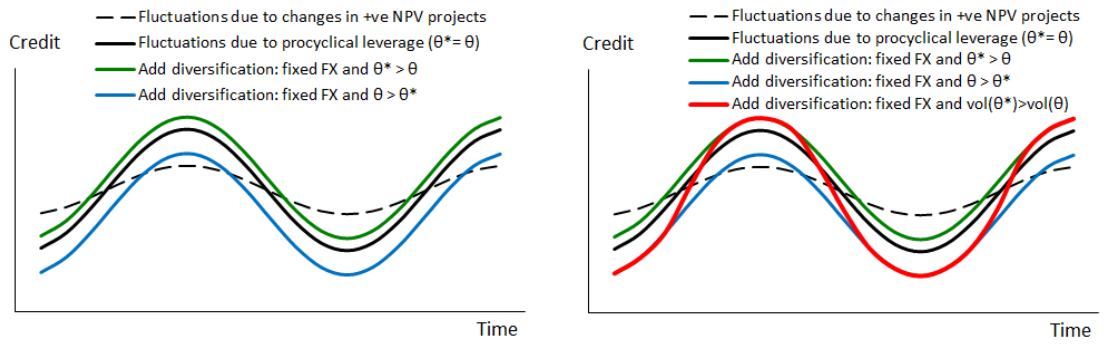
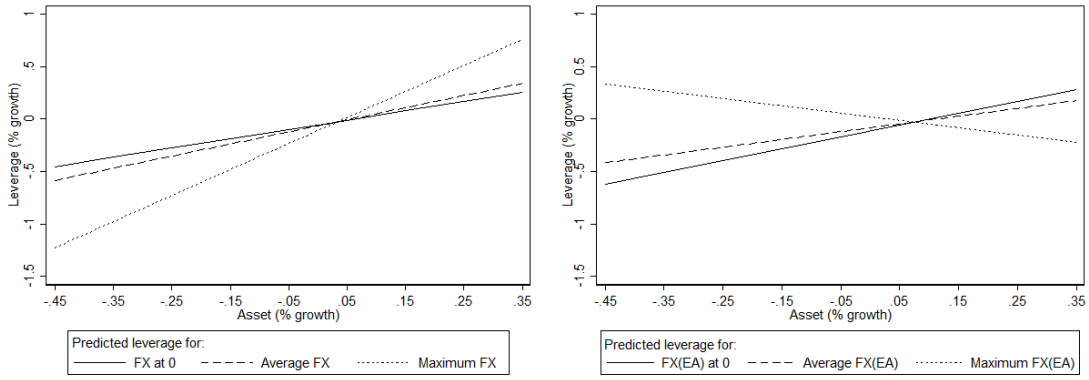


Figure 2: **Predicted leverage procyclicality and international diversification:** pre-crisis international diversification is measured in 2007 based on our sample data detailed in table 2



(a) Total diversification: FX

(b) Valuation effect:$FX(EA)$

Table 2: Summary statistics: all banks

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Leverage_{2008}	14.82	11.79	1.16	50.88	26
$\ln(\text{Asset})_{2008}$	9	2.72	5.64	14.5	26
$\Delta \ln(\text{Leverage})_{2008-2009}$	-0.15	0.24	-0.89	0.21	26
$\Delta \ln(\text{Asset})_{2008-2009}$	-0.08	0.21	-0.47	0.42	26
FX_{2007}	0.12	0.18	0	0.71	26
FX(EA)_{2007}	0.03	0.04	0	0.14	26
FX(n-EA)_{2007}	0.09	0.16	0	0.67	26
CM_{2007}	0.00	0.04	-0.11	0.1	26
CM(EA)_{2007}	0.01	0.04	-0.08	0.14	26
CM(n-EA)_{2007}	-0.04	0.08	-0.28	0.06	26
Deriv_{2007}	0.54	1.26	0	5.74	26

Δ stands for the first difference of variable between t and $t-1$.

Table 3: Summary statistics: French banks

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Leverage_{2008}	13.91	10.23	1.16	37.01	18
$\ln(\text{Asset})_{2008}$	9.49	2.9	5.64	14.5	18
$\Delta \ln(\text{Leverage})_{2008-2009}$	-0.11	0.19	-0.46	0.21	18
$\Delta \ln(\text{Asset})_{2008-2009}$	-0.02	0.2	-0.47	0.42	18
FX_{2007}	0.05	0.07	0	0.27	18
FX(EA)_{2007}	0.03	0.04	0	0.14	18
FX(n-EA)_{2007}	0.03	0.04	0	0.13	18
CM_{2007}	0.00	0.03	-0.05	0.1	18
CM(EA)_{2007}	0.01	0.04	-0.02	0.14	18
CM(n-EA)_{2007}	-0.04	0.09	-0.28	0.03	18
Deriv_{2007}	0.73	1.47	0	5.74	18

Δ stands for the first difference of variable between t and $t-1$.

Table 4: Summary statistics: foreign banks

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Leverage_{2008}	16.89	15.34	5.66	50.88	8
$\ln(\text{Asset})_{2008}$	7.89	2.01	6.24	12.49	8
$\Delta \ln(\text{Leverage})_{2008-2009}$	-0.25	0.33	-0.89	0.09	8
$\Delta \ln(\text{Asset})_{2008-2009}$	-0.19	0.2	-0.47	0.04	8
FX_{2007}	0.28	0.25	0.02	0.71	8
FX(EA)_{2007}	0.05	0.04	0	0.11	8
FX(n-EA)_{2007}	0.23	0.24	0	0.67	8
CM_{2007}	-0.01	0.05	-0.11	0.09	8
CM(EA)_{2007}	0.00	0.05	-0.08	0.09	8
CM(n-EA)_{2007}	-0.04	0.07	-0.17	0.06	8
Deriv_{2007}	0.1	0.2	0	0.55	8

Δ stands for the first difference of variable between t and $t-1$.

Table 5: Leverage procyclicality with pre-crisis international diversification

Dependent variable : $\Delta Leverage_{2008-09}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ln(Leverage_{2008})$	-0.06*	-0.05**	-0.06**	-0.07**	-0.07*	-0.06**	-0.07*	-0.08*
	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.03)
$\Delta Asset_{2008-09}$	0.88**	1.13***	0.88**	1.15***	0.84**	1.03***	0.84**	1.09***
	(0.17)	(0.06)	(0.16)	(0.08)	(0.18)	(0.07)	(0.19)	(0.11)
$\Delta Asset_{2008-09}$ x FX_{2007}	2.25*							
	(0.86)							
$\Delta Asset_{2008-09}$ x $FX(EA)_{2007}$		-13.07**						
		(2.93)						
$\Delta Asset_{2008-09}$ x $FX(n-EA)_{2007}$			2.53**					
			(0.70)					
$\Delta Asset_{2008-09}$ x $Deriv_{2007}$				-0.16**				
				(0.05)				
$\Delta Asset_{2008-09}$ x FX_{2006}					1.83*			
					(0.58)			
$\Delta Asset_{2008-09}$ x $FX(EA)_{2006}$						-10.09**		
						(2.93)		
$\Delta Asset_{2008-09}$ x $FX(n-EA)_{2006}$							1.93**	
							(0.48)	
$\Delta Asset_{2008-09}$ x FX_{2006}								-0.22
								(0.16)
FX_{2007}	-0.08			-0.13				
	(0.15)			(0.13)				
$FX(EA)_{2007}$		0.96**						
		(0.18)						
$FX(n-EA)_{2007}$			-0.10					
			(0.15)					
$Deriv_{2007}$	0.01	0.04***	0.01	-0.01				
	(0.01)	(0.00)	(0.01)	(0.01)				
FX_{2006}					-0.12			-0.21
					(0.19)			(0.19)
$FX(EA)_{2006}$						0.75**		
						(0.17)		
$FX(n-EA)_{2006}$							-0.18	
							(0.22)	
$Deriv_{2006}$					0.01	0.01**	0.01	-0.04
					(0.01)	(0.00)	(0.01)	(0.04)
Constant	0.15	-0.02	0.15	0.16	0.18	0.00	0.18	0.19
	(0.15)	(0.06)	(0.12)	(0.11)	(0.20)	(0.07)	(0.19)	(0.17)
Observations	26	26	26	26	23	23	23	23
R-squared	0.78	0.76	0.79	0.72	0.79	0.74	0.81	0.73

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Standard errors are clustered at the sub-category level. Control variables including the dummy variable for bank nationality or the sub-category dummy are reported in this table.

Table 6: Leverage procyclicality and pre-cisis currency mismatch

Dependent variable : $\Delta Leverage_{2008-09}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$ln(Leverage_{2008})$	-0.04*	-0.07**	-0.07***	-0.05**	-0.07	-0.07**	-0.08**	-0.04***
	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.02)	(0.00)
$\Delta Asset_{2008-09}$	1.03***	1.08***	1.04***	0.89**	0.88**	0.79**	0.85***	0.78*
	(0.08)	(0.08)	(0.06)	(0.22)	(0.17)	(0.15)	(0.13)	(0.30)
$\Delta Asset_{2008-09}$ x MC_{2007}	6.90***							
	(1.00)							
$\Delta Asset_{2008-09}$ x $MC(EA)_{2007}$		-1.12†						
		(0.58)						
$\Delta Asset_{2008-09}$ x $MC(n-EA)_{2007}$			6.11***					
			(0.81)					
$\Delta Asset_{2008-09}$ x $MC(dummy)_{2007}$				0.60				
				(0.31)				
MC_{2007}	1.10*							
	(0.38)							
$MC(EA)_{2007}$		-0.13*						
		(0.05)						
$MC(n-EA)_{2007}$			-0.10*					
			(0.04)					
$MC(dummy)_{2007}$				-0.01				
				(0.04)				
$Deriv_{2007}$	0.03***	0.03***	0.02***	0.02				
	(0.00)	(0.00)	(0.00)	(0.01)				
$\Delta Asset_{2008-09}$ x MC_{2006}					13.21**			
					(2.66)			
$\Delta Asset_{2008-09}$ x $MC(EA)_{2006}$						-6.74***		
						(1.10)		
$\Delta Asset_{2008-09}$ x $MC(n-EA)_{2006}$							5.21***	
							(0.57)	
$\Delta Asset_{2008-09}$ x $MC(dummy)_{2006}$								0.61
								(0.37)
MC_{2006}					1.12			
					(0.76)			
$MC(EA)_{2006}$						0.01		
						(0.06)		
$MC(n-EA)_{2006}$							-0.17***	
							(0.02)	
$MC(dummy)_{2006}$								-0.02
								(0.04)
$Deriv_{2006}$					0.01	0.01	0.00	0.00
					(0.01)	(0.00)	(0.00)	(0.01)
Constant	0.05	0.13*	0.10	0.12	0.14	0.14	0.15	0.08
	(0.06)	(0.05)	(0.05)	(0.11)	(0.13)	(0.10)	(0.09)	(0.10)
Observations	26	26	26	26	23	23	23	23
R-squared	0.75	0.71	0.76	0.76	0.80	0.82	0.81	0.74

† $p < 0.15$; * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Standard errors are clustered at the sub-category level. Control variables including the dummy variable for bank nationality or the sub-category dummy are reported in this table.

Appendix

A The model

A.1 Investment strategy

The definition of the VAR rule is based on a contract model between the bank and the bank's creditor. More specifically, a contract model a la Holmström and Tirole [1997] implies an investment choice made by the bank between two types of portfolio. The first portfolio $\{H, H^\star\}$ is a "good" portfolio with a total expected return of $[ar_H + (1-a)r_{H^\star}]$. r_H and $r_{H^\star}$ denote the expected return of the good domestic asset and the good foreign asset, respectively. The second portfolio $\{L, L^\star\}$ is not as good as $\{H, H^\star\}$. Its total expected return $[ar_L + (1-a)r_{L^\star}]$ is reduced through a parameter k $(k > 0)$ and its volatility is increased by a parameter m $(m > 1)$. Domestic returns follow a General Extreme Value (GEV) distribution with a location parameter θ. Similarly, foreign returns follow a GEV distribution with a location parameter $\theta^\star$. θ and $\theta^\star$ are proxies for the state of the domestic and foreign economies at the time of investment.

I use a mixture of GEV distributions to define the Cumulative Distribution Function (CDF) of portfolio return. The total portfolio expected return then depends on θ and $\theta^\star$. Considering that the bank and the creditor of the bank are risk neutral, preference for the domestic asset and home bias are not considered in this model.[29] The definition of assets supports this hypothesis. For each asset class - good or less good - the only difference between the domestic and the foreign asset is the location parameter. Parameters relative to asset volatility are similar. When the bank invests in the good

[29] However, the model is flexible enough to introduce some frictions in the definition of a and $(1-a)$ to introduce an home bias.

portfolio, the CDF is defined such that: [30]

$$
\begin{aligned}
F_{H,H^\star}(z) &= a\, F_H(z) + (1-a)\, F_{H^\star}(z) \\
&= a\, exp\left\{-\left(1+\xi\left(\frac{z-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} + (1-a)\, exp\left\{-\left(1+\xi\left(\frac{z-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}
\end{aligned}
\tag{A.1}
$$

Because the ex-post value of assets is stochastic, there is a risk that the value of assets may be lower than the value of debts, leading to a default. Therefore, the CDF defines the probability of default α when the bank invests in the good portfolio. Default appears if the realized total return falls below the total debt ratio at the notional value ($(\bar{d}+\bar{d}^\star) \geq z$). It implies that α increases with z but decreases with θ and $\theta^\star$.[31] The probability of default α is defined such that:[32]

$$
\begin{aligned}
\alpha(\bar{d}+\bar{d}^\star) &= F_{H,H^\star}(\bar{d}+\bar{d}^\star) \\
&= a\, exp\left\{-\left(1+\xi\left(\frac{(\bar{d}+\bar{d}^\star)-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\} \\
&\quad + (1-a)\, exp\left\{-\left(1+\xi\left(\frac{(\bar{d}+\bar{d}^\star)-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}
\end{aligned}
\tag{A.2}
$$

Since the creditor is uninsured, he/she holds a defaultable debt claim with respect

[30] Where: $F_H(z) = exp\left\{-\left(1+\xi\left(\frac{z-\theta}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}$, $F_{H^\star}(z) = exp\left\{-\left(1+\xi\left(\frac{z-\theta^\star}{\sigma}\right)\right)^{-\frac{1}{\xi}}\right\}$
$F_L(z) = exp\left\{-\left(1+\xi\left(\frac{z-(\theta-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\}$, and $F_{L^\star}(z) = exp\left\{-\left(1+\xi\left(\frac{z-(\theta^\star-k)}{\sigma m}\right)\right)^{-\frac{1}{\xi}}\right\}$
Where θ, σ and ξ are respectively the location parameter, the scale parameter and the shape parameter. Note that this framework using a mixture distribution is still compatible with a Second Order Stochastic Dominance, as in the reference model.
See Reiss and Thomas [2007] for more details on GEV distributions.

[31] Note that z enters in both terms of the probability of default equally. Only the total debt level matters in the definition of the probability of default, regardless of the composition of liabilities. As for assets, there is no home bias or preference for domestic debt. Domestic and foreign debts are commutable. Discussion on the impact of the foreign exchange rate on liabilities conditional on the composition of the balance sheet is detailed in Section 4.

[32] Alternatively, the probability of default when the bank invests in the "less good" portfolio can be defined through $F_{L,L^\star}(\bar{d}+\bar{d}^\star)$. However, I focus on the good portfolio since the contract between the bank and its creditor leads to this portfolio.

to the funds lent to the bank at T=0. Following Merton [1974], the value of this defaultable debt claim with strike price $(\bar{D} + S\bar{D}^{\star})$ can be divided into two components: cash $(\bar{D} + S\bar{D}^{\star})$ and a short position on a put option $\pi_{H,H^{\star}}$ or $\pi_{L,L^{\star}}$, depending on the investment choice.

A.2 Participation and incentive constraints

The definition of $(d + d^{\star})$ and leverage come from the maximization of the utility of the bank and the creditor. The creditor of the bank is risk neutral. He maximizes his utility U^{C} defined as his total net expected payoff. His net expected payoff is the difference between the value of his defaultable debt claim and the total funds provided to the bank. If the bank invests in the good portfolio, the net expected payoff is given by:

$$U^{C}_{H,H^{\star}}(A + SA^{\star}) = (A + SA^{\star})\left[(\bar{d} + \bar{d}^{\star}) - \pi_{H,H^{\star}}(\bar{d} + \bar{d}^{\star}) - (d + d^{\star})\right] \tag{A.3}$$

The requirement that utility is equal to or higher than 0 provides the first Participation Compatibility (PC) constraint of the creditor. This constraint binds in the optimal contract:

$$\begin{aligned} 0 &\leq (\bar{d} + \bar{d}^{\star}) - \pi_{H,H^{\star}}(\bar{d} + \bar{d}^{\star}) - (d + d^{\star}) \\ (d + d^{\star}) &= (\bar{d} + \bar{d}^{\star}) - \pi_{H,H^{\star}}(\bar{d} + \bar{d}^{\star}) \end{aligned} \tag{A.4}$$

Similarly for an investment in the bad portfolio:

$$(d + d^{\star}) = (\bar{d} + \bar{d}^{\star}) - \pi_{L,L^{\star}}(\bar{d} + \bar{d}^{\star}) \tag{PC}$$

The PC constraint defines the total debt ratio at market value relative to the total debt ratio at notional value. The latter should be large enough to form an incentive for the creditor to participate. The higher the reimbursement offered by the bank, the more

the creditor is tempted to lend money at T=0.

The bank is risk neutral and maximizes its expected utility U^B defined as its total net expected payoff. The net expected payoff when the bank invests in the good portfolio is equal to:

$$U^B_{H,H^\star} = (A + SA^\star)\left[a.r_H + (1-a)r_{H^\star} + (d + d^\star) - (\bar{d} + \bar{d^\star}) + \pi_{H,H^\star}(\bar{d} + \bar{d^\star})\right] \quad \text{(A.5)}$$

When the bank invests in the bad portfolio the net expected payoff is equal to:

$$U^B_{L,L^\star} = (A + SA^\star)\left[a.r_L + (1-a)r_{L^\star} + (d + d^\star) - (\bar{d} + \bar{d^\star}) + \pi_{L,L^\star}(\bar{d} + \bar{d^\star})\right] \quad \text{(A.6)}$$

Assuming that $U^B_{H,H^\star} \geq U^B_{L,L^\star}$, the Incentive Compatibility (IC) constraint is given by:[33]

$$r_H - r_L \geq \Delta\pi(\bar{d} + \bar{d^\star}) \quad \text{(A.7)}$$
$$\text{Where : } \Delta\pi(\bar{d} + \bar{d^\star}) = \pi_{L,L^\star}(\bar{d} + \bar{d^\star}) - \pi_{H,H^\star}(\bar{d} + \bar{d^\star})$$

The IC constraint stipulates that there is a solution $(\bar{d} + \bar{d^\star})$ that satisfies this inequality. The unique solution illustrated in figure A.1 comes from the Second Order Stochastic Dominance (SOSD) between the two mixture distributions and the differential in volatility. The surface area $\Delta\pi(z)$ increases until $F_{H,H^\star}(z) = F_{L,L^\star}(z)$ and decreases after the junction. As shareholders receive returns, $(\bar{d} + \bar{d^\star}) < a(1 + \bar{r}) + (1-a)(1 + \bar{r}^\star)$,

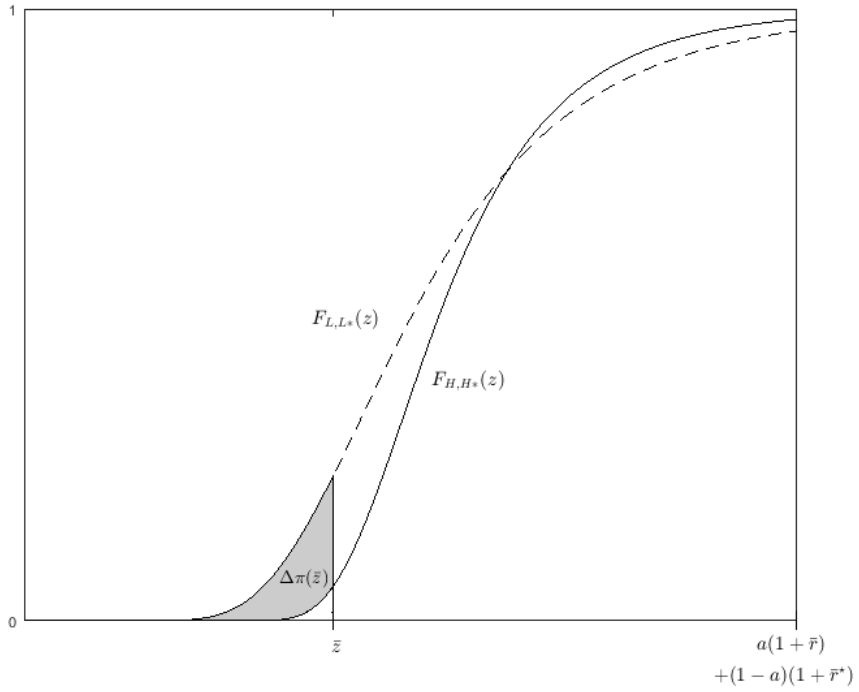
[33] Where:

$$\begin{aligned} r_H - r_L &= \theta + \sigma H(\xi) - (\theta - k) - m\sigma H(\xi) \\ &= k - \sigma(m-1)H(\xi) \\ r_{H^\star} - r_{L^\star} &= \theta^\star + \sigma H(\xi) - (\theta^\star - k) - m\sigma H(\xi) \\ &= k - \sigma(m-1)H(\xi) \end{aligned}$$

there is a unique solution $\bar{z} = (\bar{d} + \bar{d}^{\star})$ which satisfies the IC constraint.

$$r_H - r_L = \Delta\pi(\bar{d} + \bar{d}^{\star}) \qquad \text{(IC)}$$

Figure A.1: **The incentive compatibility constraint from the bank expected payoff:** a unique solution $\bar{z}$. This chart plots the distribution functions $F_{H,H^{\star}}$ and $F_{L,L^{\star}}$ for ξ= 0.1, θ=$\theta^{\star}$=0.5, σ= 0.1, k= 0.05, and m= 1.4. The dark line indicates $F_{H,H^{\star}}$ and the dash line indicates $F_{L,L^{\star}}$.



The IC constraint also represents the moral hazard trade-off from Holmström and Tirole [1997]. The lhs of IC represents the bank private benefit from investing in the good portfolio while the right hand side (rhs) is equal to the private benefit from investing in the bad portfolio (e.g. low effort in the moral hazard model of Holmström and Tirole [1997]). With the added PC constraint from the creditor, the bank necessarily invests in the good portfolio where the put option induces lower prices.

The unique solution is such that:

$$
\begin{aligned}
(r_H - r_L) &= \Delta\pi(\bar{d} + \bar{d^\star}) \\
&= \int_0^{\bar{d}+\bar{d^\star}} F_{L,L^\star}\,\mathrm{d}z - \int_0^{\bar{d}+\bar{d^\star}} F_{H,H^\star}\,\mathrm{d}z \\
&= e^{\frac{k}{\sigma}} \int_0^{\bar{d}+\bar{d^\star}} F_{H,H^\star}\,\mathrm{d}z - \int_0^{\bar{d}+\bar{d^\star}} F_{H,H^\star}\,\mathrm{d}z \\
&= (e^{\frac{k}{\sigma}} - 1) \int_0^{\bar{d}+\bar{d^\star}} F_{H,H^\star}\,\mathrm{d}z \\
&= (e^{\frac{k}{\sigma}} - 1)\sigma F_{H,H^\star}(\bar{d} + \bar{d^\star})
\end{aligned}
\tag{A.8}
$$

Combining the unique solution with the definition of the probability of default α and assuming that $\xi = -1$ and $m \mapsto 1$, the VaR rule is expressed as a closed-form solution such that :[34]

$$
\alpha = F_{H,H^\star}(\bar{d} + \bar{d^\star}) = \frac{(r_H - r_L)}{(e^{\frac{k}{\sigma}} - 1)} \tag{A.9}
$$

where $\frac{(r_H - r_L)}{(e^{\frac{k}{\sigma}} - 1)}$ is a constant equal to $\bar{\bar{\alpha}}$.

A.3 Combining risk and currency channels

When both the risk and the currency channels are included, the total ratio of notional values of debt $(\bar{d} + \bar{d^\star})$ is defined by:

$$
(\bar{d} + \bar{d^\star}) = \theta + \sigma + \sigma ln\,(\bar{\bar{\alpha}}) - \sigma ln\left(a_{(S,\theta,\theta^\star)} + (1 - a_{(S,\theta,\theta^\star)})\; exp\left\{\frac{\theta - \theta^\star}{\sigma}\right\}\right) \tag{A.10}
$$

[34] $\xi = -1$ implies that the $F_{\theta,\theta^\star}(z)$ distribution has an upper bound: the support of the distribution is $\left(-\infty\,,\; -\sigma ln\left(a.exp\left\{-\left(\frac{\sigma+\theta}{\sigma}\right)\right\} + (1-a)exp\left\{-\left(\frac{\sigma+\theta^\star}{\sigma}\right)\right\}\right)\right)$. As the VaR rule focuses on the left side of the distribution, this assumption is not a problem. $m \mapsto 1$ makes the volatility between the good and the bad asset comparable. It allows an approximation of a closed form solution.

Assuming that θ is constant, the adjustment of $(\bar{d}+\bar{d}^{\star})$ relative to a change in $\theta^{\star}$ is derived such that:

$$\frac{d(\bar{d}+\bar{d}^{\star})}{d\theta^{\star}} \mid \theta = \underbrace{1-\frac{a}{a+(1-a)exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}}}_{Risk\ Diversification} \underbrace{-\sigma\frac{\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}} \mid \theta\right)\left(1-exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}\right)}{a+(1-a)exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}}}_{Valuation} \tag{A.11}$$

The derivative is composed of two effects: the risk diversification effect and the valuation effect. When the exchange rate is fixed (i.e $\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}}=0$), the derivative is limited to the risk diversification effect. It is equal to 0, 1 and $(1-a)$ when $a=1$, $a=0$ and $\theta=\theta^{\star}$, respectively. When the states of nature become different $\theta \neq \theta^{\star}$ with θ being fixed, an international diversification such that $a>0$ reduces the procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to $\theta^{\star}$: the stability of the domestic state of nature anchors the tail risk of asset portfolio.

A floating exchange rate introduces a valuation effect as long as $\theta \neq \theta^{\star}$. Its impact on the adjustment of $(\bar{d}+\bar{d}^{\star})$ relative to a change in $\theta^{\star}$ depends on the adjustments of the foreign state of nature. When the foreign economy is booming $(\theta^{\star}>\theta)$, the valuation effect is positive and increases the procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to $\theta^{\star}$. The foreign economic condition implies a depreciation of the domestic currency and a decrease in the share of the domestic asset in the bank portfolio: the tail risk is reduced. Similarly, when the foreign economy is busting, $\theta^{\star}<\theta$, the valuation effect is negative and reduces the procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to $\theta^{\star}$. The floating exchange rate promotes the domestic asset which performs relatively better than the foreign one because of domestic currency appreciation. In both cases, a floating exchange rate increases the fund raising capacity of banks. However, the adjustment of $(\bar{d}+\bar{d}^{\star})$ relative to $\theta^{\star}$ may become counter-cyclical if the valuation effect is large enough to compensate the risk diversification effect when

the foreign economy is busting. A counter-cyclical $(\bar{d}+\bar{d}^{\star})$ is observed when $\theta^{\star} < \theta$ and:

$$\underbrace{(1-a)\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}} \mid \theta\right)^{-1}}_{Portfolio\,adjustment} < \sigma \underbrace{\left(\frac{1}{exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}} - 1\right)}_{\Delta Economic\,condition} \tag{A.12}$$

The counter-cyclical condition compares the portfolio adjustment due to the valuation effect to the relative economic growth starting from $\theta = \theta^{\star}$. Because $\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta^{\star}} \mid \theta\right) < 0$, the higher the initial share of foreign asset, the more validated the condition.

Inversely when $\theta^{\star}$ is constant, the adjustment of $(\bar{d}+\bar{d}^{\star})$ relative to a change in θ can be derived such that:

$$\frac{d(\bar{d}+\bar{d}^{\star})}{d\theta} \mid \theta^{\star} = \underbrace{\frac{a}{a+(1-a)exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}}}_{Risk\ Diversification} - \underbrace{\sigma\frac{\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta} \mid \theta^{\star}\right)\left(1-exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}\right)}{a+(1-a)exp\left\{\frac{\theta-\theta^{\star}}{\sigma}\right\}}}_{Valuation} \tag{A.13}$$

The derivative is equal to 0, 1 and a if $a = 0$, $a = 1$ and $\theta = \theta^{\star}$, respectively. The procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to a change in θ decreases when $\theta \neq \theta^{\star}$ with $\theta^{\star}$ and S being fixed, and $(1-a) > 0$: the stability of the foreign state of nature anchors the tail risk of asset portfolio. A floating exchange rate with $\theta \neq \theta^{\star}$ introduces a valuation effect which depends on economic conditions. When $\theta > \theta^{\star}$, the domestic economy outperforms the foreign one and the domestic currency appreciates, implying that $\left(\frac{da_{(S,\theta,\theta^{\star})}}{d\theta} \mid \theta^{\star}\right) > 0$. The share of the domestic asset in bank portfolio raises and the bank fund raising capacity increases: the valuation effect increases the procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to θ. Inversely, when $\theta < \theta^{\star}$, bank fund raising capacity decreases the procyclicality of $(\bar{d}+\bar{d}^{\star})$ relative to θ. When the valuation effect is strong enough to compensate the domestic bust, the adjustment of $(\bar{d}+\bar{d}^{\star})$ relative to θ is counter-cyclical

if:

$$\underbrace{a\left(\frac{da_{(S,\theta,\theta^\star)}}{d\theta} \mid \theta^\star\right)^{-1}}_{Portfolio\,adjustment} < \underbrace{\sigma\left(1 - exp\left\{\frac{\theta - \theta^\star}{\sigma}\right\}\right)}_{\Delta Economic\,condition} \tag{A.14}$$

The lower the initial share of domestic asset in the bank portfolio, the more the bank benefits from the valuation effect and the more validated the condition would be.

A.4 Theoretical predictions

Table A.1: **Impact of international diversification on leverage procyclicality.** The comparative is the baseline leverage procyclicality (i.e. without international diversification), or the leverage procyclicality under the fixed exchange rate regime for the impact of floating exchange rate regime.

Generalized conclusions with fixed FX and positive correlation between θ and $\theta^\star$:
$\sigma_{\theta^\star} < \sigma_\theta$: Less procyclical
$\sigma_{\theta^\star} > \sigma_\theta$: More procyclical
$\sigma_{\theta^\star} = \sigma_\theta$: Unchanged

	During booms:	During busts:
Similar economies: $\theta^\star = \theta$		
Fixed FX	Unchanged	Unchanged
$\hookrightarrow$ *Introducing floating FX*	*Unchanged*	*Unchanged*
Foreign economy outperforms: $\theta^\star > \theta$		
Fixed FX	More procyclical	Less procyclical
$\hookrightarrow$ *Introducing floating FX*	*Procyclicality* $\nearrow$	*Procyclicality* $\searrow$ *(Potentially counter-cyclical)*
Domestic economy outperforms: $\theta > \theta^\star$		
Fixed FX	Less procyclical	More procyclical
$\hookrightarrow$ *Introducing floating FX*	*Procyclicality* $\nearrow$	*Procyclicality* $\searrow$ *(Potentially counter-cyclical)*

B Dataset

The final database I use is a combination different databases collected by the French banking supervision authority (ACPR) including the following eSurfi tables: {SITUATION, BILA_CONS, F_01.00, F_11.01, DEVI_SITU}. Accounting data including total assets, leverage and derivatives are collected at the book value for the highest level of consolidation. For large international banks, data are consolidated using the IFRS accounting standard and collected in Finrep tables {F_01.00, F_11.01}. Smaller parent banks provide consolidated data using the French accounting standards (FRGAAP) in {BILA_CONS}, while stand-alone banks provide unconsolidated data reported in the {SITUATION} table. Data on currency exposures (from DEVI_SITU) are collected at the book value and at an individual level for all banks (unconsolidated data). The proxy of asset international diversification adds up currency exposures of all affiliates in the same banking group. International diversification is then an aggregate measure of the currency exposure at the banking group level.

C Discussion on home bias and retrenchment

The model developed in this paper does not consider home bias in lending. Banks and creditors are risk neutral agents that adjust their activities relative to portfolio characteristics and expected value of return and reimbursement. Banks adjust leverage to increased risk in equal manner whether risk comes from home or from the foreign economy. The home bias theory suggests that banks are more sensitive to shocks abroad. Considering home bias behavior, the adjustment of banking activities linked to the risk channel of diversification - as defined in the model - would be exacerbated by a general retrenchment of foreign exposures because of risk aversion of domestic banks. Although home bias is not presented in the model, it is consistent with the risk channel of diversi-

fication. In both mechanisms, an increase in foreign risk leads to a decrease in banking activity. This reaction could be stronger considering home bias.

Table C.1 details alternative specifications and results to discuss the home bias behavior. Column 1) decomposes procyclicality of leverage considering resident (i.e. euro area) and non-resident (i.e. non euro area) exposure of assets. Results suggest that leverage adjustment between 2008 and 2009 depended positively and significantly on both exposures. Under the home bias hypothesis, one might expect that the coefficient relative to the non-resident exposure to be larger than the coefficient relative to the domestic exposure. Such a result would have provide some evidences of significant home bias behavior and banks' risk aversion. Currency diversification is introduced in column 2) with an interaction variable between currency diversification and the two types of exposures. Currency diversification might reduce procyclicality relative to domestic exposure, however it is not significant (i.e. the coefficient of the interaction variable between changes in assets relative to resident exposure and diversification is negative and insignificant). Regarding procyclicality relative to non-resident, the coefficient of the interaction variable between changes in assets relative to non-resident and currency diversification is positive and significant. It suggests that currency diversification drives the effect and explains leverage procyclicality beyond home bias behavior that focuses on counterparty exposure.

Column 3) and 4) of table C.1 focus on the heterogeneity between French and foreign banks. Focusing on total assets in column 3), the coefficient of the changes in assets is positive and significant while the coefficient of the interaction variable is negative and significant. Because the sum of coefficients is still positive and significant at 1%, both groups of banks are procyclical but foreign banks are more procyclical than French banks. This result is consistent with both the risk channel of diversification and the

home bias behavior. Foreign banks were the most exposed to the US in 2007, implying that they faced a larger increase in risk compared to French banks. Following the VaR rule, foreign banks adjusted their leverage more aggressively than French banks to match their portfolio risk and keep their default probability constant. Alternatively, the home bias hypothesis would suggest that foreign banks located in France are more procyclical than French banks because they are the primary adjustment variable of foreign parent banks located in their home country. Column 4) decomposes total assets into resident and nonresident assets. The coefficients on the changes in resident and nonresident assets are positive and significant. This suggests that foreign banks are pro-cyclical with respect to domestic and foreign exposures. For French banks, the results suggest that the procyclicality of banks comes from total asset exposure. The sum of the coefficients for resident exposure or nonresident exposure is not significantly different from zero. The home bias hypothesis suggests that exposure to non-residents would be sufficient to explain procyclicality.

While home bias behavior is certainly included in the procyclical behavior of bank leverage, the results suggest that currency diversification captures additional information that gives another dimension to the analysis. Assuming that bank behavior is driven by the home bias hypothesis, all results would be driven by bank exposure to nonresidents and currency diversification would have no explanatory power. The home bias is consistent with the international diversification risk channel, however, the currency channel that focuses on the foreign currency of denomination (i.e. with domestic exposure) differs from it.

Table C.1: Leverage procyclicality, pre-crisis international diversification and home bias behavior

Dependent variable : $\Delta Leverage_{2008-09}$

	(1)	(2)	(3)	(4)
$ln(Leverage_{2008})$	-0.07***	-0.05***	-0.05***	-0.09***
	(0.00)	(0.00)	(0.01)	(0.00)
$\Delta Asset\ Resident_{2008-09}$	0.58***	0.77***		0.30***
	(0.03)	(0.11)		(0.05)
$\Delta Asset\ non\text{-}Resident_{2008-09}$	0.37**	0.16		1.04*
	(0.06)	(0.12)		(0.33)
$\Delta Asset\ Resident_{2008-09}$ x FX_{2007}		-0.22		
		(0.29)		
$\Delta Asset\ non\text{-}Resident_{2008-09}$ x FX_{2007}		2.78***		
		(0.37)		
$\Delta Asset$			1.69***	
			(0.09)	
$\Delta Asset$ x FR			-0.97***	
			(0.10)	
$\Delta Asset\ Resident_{2008-09}$ x FR				-0.11
				(0.14)
$\Delta Asset\ non\text{-}Resident_{2008-09}$ x FR				-1.25*
				(0.43)
FX_{2007}		0.23**		
		(0.04)		
FR			-0.17***	-0.03
			(0.00)	(0.03)
$Deriv_{2007}$	0.10**	0.06	0.01**	-0.12
	(0.03)	(0.05)	(0.00)	(0.07)
$Constant$	-0.03***	0.01	0.18***	0.23**
	(0.00)	(0.02)	(0.01)	(0.04)
Observations	26	26	26	26
R-squared	0.60	0.88	0.81	0.79

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Standard errors are clustered at the sub-category level. Control variables including the dummy variable for bank nationality or the sub-category dummy are reported in this table.